CHAPTER 2: HUMAN FACTORS AND HUMAN ERROR

There are numerous references that provide definitions for, classifications of, and approaches for addressing human error and human factors. [1,2,3,4,5,6,9] The intent of this chapter is to familiarize the reader with the concepts that will be referenced throughout the remaining chapters of this guidance document, and the concepts that were used to formulate the general approach of this guidance document. It is not the intent of this chapter to present and compare the numerous definitions, classifications, and approaches that exist regarding human factors and human error. The reader is directed to the references provided in this section for additional information.

2.1 DEFINITIONS

For the purpose of this guidance document:

- Human Factors is defined as "A discipline concerned with designing machines, operations, and work environments so that they match human capabilities, limitations, and needs".[2]

- Human Factors can be further referred to as "…environmental, organizational, and job factors, and human and individual characteristics which influence behavior at work in a way which can affect health and safety."[9]

- Human Error is defined as "Departure from acceptable or desirable practice on the part of an individual that can result in unacceptable or undesirable results".[5]

2.2 CLASSIFICATIONS

Before a source can manage human factors and error, it may be useful to understand where and how human factors and error initiate. Literature commonly refers to active failures and latent conditions in describing where human factors and error originate and occur.[6& 9] Active failures are errors and violations committed by people at the human–system interface such as operators and maintenance personnel. These failures are usually unique to a specific event and have immediate effects. Latent conditions arise due to decisions made throughout the organization (e.g., marketing personnel, designers, managers) and outside of the organization (e.g.,regulating agencies). Latent conditions exist in all systems and may lie unrecognized until combining with active failures to result in an incident. The same latent condition may contribute to a number of different accidents. An example of active failures and latent conditions is "the design of a scrubbing system may not be adequate to handle all credible releases. If an active human error initiates the production of an excessive volume of product the system may allow toxic materials to be released to the environment."[1]

Active failures or malfunctions can be classified as malfunctions of commission (actions taken by individuals that can lead an activity to realize a lower safety than intended) and malfunctions of omission (actions NOT taken by individuals that can lead an activity to realize a lower safety than intended)[5]. Malfunctions can be further described by the types of error mechanisms: slips and lapses; mistakes; and violations. Slips are defined as errors in which the intention is correct but failure occurs when carrying out the activity required[1]. For example, a worker may know that Pump 1 must be isolated for maintenance, but instead closes the suction and discharge valves on Pump 2. Lapses are defined as an error in operator recall[5]. Lapses cause us to forget to carry out an action, to lose our place in a task or even to forget what we had intended to do. Lapses can be reduced by minimizing distractions and interruptions[9]. Mistakes are defined as an error in establishing a course of action. Mistakes develop when the action was intended but the intention was wrong. Mistakes can be caused by inappropriately applying rules, procedures, or reasoning based on first principles or analogies.

Violations are defined as errors when an intended action is made that deliberately ignores known operations rules, restrictions, or procedures (excluding sabotage). Violations are divided into three categories: routine, optimizing, and necessary. Routine violations involve "short-cuts" or "corner cutting" (i.e., breaking the rule has become the normal way of working). Optimizing violations involve violations for the thrill of it (e.g., increasing throughout-put to see if the system can handle it). Necessary violations involve situations were non-compliance is necessary to complete the job (e.g., an operator is not provided the right tools to perform a job). Stationary source may reduce violations by[9]:

- Taking steps to increase the chances of violations being detected (e.g., monitoring)
- Thinking about where there are unnecessary rules
- Making rules and procedures relevant and practical
- Explaining the reasons behind certain rules or procedures and their relevance
- Considering violations during risk assessments
- Reducing time pressure on staff to act quickly in novel situations

Individuals are more likely to conduct slips and lapses, and mistakes depending on the performance level of the task they are performing. Information processing or performance levels involved in industrial tasks have been classified in accordance with the Skill-, Rule-, and Knowledge-based (SRK) approach.[1] These types of information processing – skill, rule, and knowledge- are differentiated by the degree of conscious control exercised by the individual. Knowledge-based mode requires the highest degree of consciousness. There are no rules for handling the situation and individuals must improvise (e.g., troubleshooting during an upset condition). Rule-based mode requires the next highest degree of consciousness. This requires individuals to follow or apply previously developed rules or procedures (e.g., a pilot completing the checklist prior to take-off). The final mode, skill-based, requires little conscious attention (e.g., a driver switching gears in a manual-transmission automobile). Slips and lapses most often occur during the skill-based mode while mistakes can occur during the rule-based or knowledge-based modes.

2.3 APPROACH

There are various existing approaches for describing and evaluating the role of human error and human factors in incidents, and for addressing the source of human factors and error. The following brief narratives are not intended to provide a comprehensive discussion on each approach, rather they are intended to briefly describe the approach and to direct the reader to alternative resources for additional information.

2.3.1 "Swiss Cheese" Model of Defences

The systems and defenses are lined up as barriers against a triggering event becoming an incident or accident. Each of these barriers has ever-changing "holes" resulting from latent conditions and active failures. If the "holes" created from latent conditions and active failures line up in successive defenses or systems, the result is an opportunity for an incident.[6]

2.3.2 Microergonomic Approach

Microergonomics addresses the relationship between human, equipment, and the physical environment[7]. It is focused on the human-machine system level and is, for example, concerned with the design of individual workstations, work methods, tools, control panels, and displays. Microergonomic considerations address:

- Materials handling
- Machinery design
- Workstation design
- Handtool design

2.3.3 Macroergonomic Approach

Macroergonomics is focused on the overall people-technology system level and is concerned with the impact of technological systems on organizational, managerial, and personnel systems. [7] Human error within the macroergonomic approach is considered a result of the interface between workers and their environment or system.[8] The human system interface is comprised of three different dimensions:

- Situation based – those related to the immediate work environment in time and space (e.g., complicated workstation, wet work surface)
- Management based - (e.g., failures in communication, leadership, failure to train people, rewards system)
- Human based – (e.g.,emotional states, moral, motivation)

2.3.4 Human and Organizational Factors (HOF)

Human and organizational factors can be related to the individuals that design, construct, operate, and maintain the system. [5] The actions or inactions of these individuals are influenced by four components:

- The organizations that they work for
- The procedures (formal, informal, software) they use to perform their activities
- The structure and equipment involved in these activities
- The environments in which the individual conducts activities.

Malfunctions can occur with the individual, with one of the preceding four components, or at the interfaces between the components and the individual.

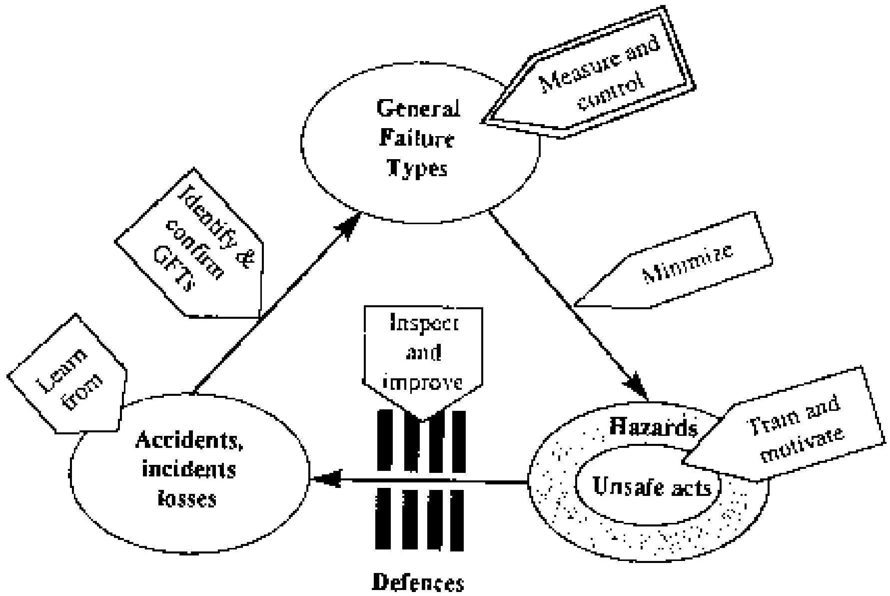
2.3.5 ERROR MANAGEMENT AND TRIPOD-DELTA APPROACH

Error management is made up of error reduction and containment[6]. It must be directed at the following levels:

- The individual and the team
- The task
- The workplace
- The organizational processes

One method for error management is the application of the Tripod–Delta method for revealing and correcting error-producing factors at both the workplace and the organizational levels. The method is depicted below in a figure taken from "Managing Risks of Organizational Error". [6] This method is comprised of three main elements and includes the safety management actions necessary at each stage. The first element is the performance of unsafe acts which facilities usually attempt to remedy through training and employee motivation. If these unsafe acts breech the existing defences of the facility, an accident, incident, or loss may occur. Facilities should routinely inspect and improve the defences to protect against an accident, incident, or loss. Once an incident occurs, the facility should investigate the event to identify the latent conditions that may have contributed to the event. The facility should also establish a method for identifying and managing latent conditions, or General Failure Types. This in turn can result in a minimization of the performance of unsafe acts.

The Tripod-Delta approach identified eleven General Failure Types: hardware, design, maintenance management, procedure, error-enforcing conditions, housekeeping, incompatible goals, communications, organization, training, and defences. The approach requires that the facility derive a checklist of specific indicators for each of the General Failure Types. The task specialists (e.g., operators, maintenance personnel) are then asked to complete the checklist.



2.3.6 SAFETY MANAGEMENT

Three approaches to safety management exist to address the different dimensions or components described in Sections 2.3.3, 2.3.4, and 2.3.5 above[6]. These approaches are referred to as the person model, the engineering model, and the organizational model. The person model is widely applied and uses tactics such as rewards and discipline, training, and writing procedures. The engineering model focuses on the influence of the physical workplace on the performance of individuals (e.g., operators at a refinery being influenced by the control panel and the information provided by the control system). The organizational model focus on the human error being a consequence of existing latent errors in the system.

2.4 GENERAL APPROACH OF THE GUIDANCE DOCUMENT

Comprehensive human factors programs must develop methods for evaluating and resolving active failures and latent conditions initiated within the following four dimensions or at the interfaces between the dimensions:

- Individuals (e.g., motivation, emotional states)
- The activity or task being conducted, including the procedures for the activity or task (e.g., routine, non-routine, written, practice, formal, informal)
- The physical environment (e.g., equipment) or workplace
- Management or organization (e.g., poor communication, reward and discipline system)

The goal of the guidance document is to develop the requirements from County Ordinance 98-48 (See Chapter 1) to ensure that sources will evaluate and resolve failures and conditions initiated within the previous four dimensions. Stationary sources must identify potential unsafe acts or active failures occurring in hazardous circumstances. They must also assess the adequacy of their existing safeguards and incorporate improvements if necessary. Both of these requirements can be fulfilled by conducting traditional and possibly procedural PHA's. When incidents and accidents do occur, sources must perform incident investigations to identify the active failures and existing latent conditions that contributed to the incident. The latent conditions identified during the incident investigation must be incorporated into a program developed to manage and control latent conditions. Other programs must also be developed and implemented to manage and control latent conditions including a management of change procedure to review staffing changes, a program for developing high quality procedures, and a program for developing a sound management system. Minimization of latent conditions should result in fewer unsafe acts or active failures or at least reduced risk from the unsafe acts and active failures that do occur.

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[1] CCPS, Guidelines for Preventing Human Error in Process Safety (1994)
[2] CMA, A Manager's Guide to Reducing Human Errors
[3] J. Moraal, Human Factors in Loss Prevention, paper from International conference on Hazard Identification and Risk Analysis, Human Factors and Human Reliability in Process Safety (1992)
[4] Reason, J., Human Error (1998)
[5] Bea, Holdsworth, and Smith, "Human and Organization Factors in the Safety of Offshore Platforms", a paper presented at the 1996 International Workshop on Human Factors in Offshore Operations
[6] Reason, J., Managing the Risks of Organizational Accidents (1998)
NOTE: Tripod-Delta was developed for Shell Intl. Petroleum Corporation by a joint research team from Leiden U. (Wagenaar) and the U. of Manchester
[7] Meshkati, Najmedin, "Human Factors in Process Plants and Facility Design" chapter 6 of Cost-Effective Risk Assessment for Process Design (1995)
[8] Imada, Andy, A Macroergonomic Approach to Reducing Work Related Injuries (1998)
[9] Reducing Error and Influencing Behavior, HSG48, HSE (1999)